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Integrating Mathematics and Methods

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I would like to discuss a two-semester integrated mathematics content and methods course for preservice elementary school teachers taught for the past twenty years at Saint Xavier University. What makes this course truly innovative is that the integration is accomplished by presenting the material in a problem-solving format in a laboratory context, with students working with manipulative materials as part of a cooperative group. Such a format allows prospective elementary school teachers to (re)learn mathematics and learn about the teaching of mathematics in a way they have not been exposed to previously and in a way which is consistent with the NCTM Curriculum and Evaluation Standards. Thus, it sets a compelling paradigm for similar courses at other institutions to examine and emulate. At the very least, it will start, I hope, a dialogue about the desirability of integrating mathematics and teaching methods into one course.

The course under discussion is conducted in a typical laboratory model. Students sit in groups of three, four, or possibly five around a table. In the cupboards surrounding the room are all the materials available for students to use to solve problems or answer questions posed in the laboratory manual, by the teacher or another student. These materials include Cuisenaire rods, counters, base ten blocks, weights, balances, meter sticks, textbook series from various companies, geoboards, etc. as well as pairs of scissors, paper clips, rubber bands, tape, and so on. Although some materials are suggested for use in the manual, students are free to use whatever materials they want. Students are aware of the problems they will be working on during any particular day, and so are expected to have at least read the appropriate materials prior to the class meeting. At times there are preparations which must be done at home. For example, there might be reading assignments, or, after constructing a meter measure using ten decimeter lengths of construction cardboard, students are asked to find at least two objects (for each of the following) which are approximately ten centimeters long, a meter long, or a square decimeter.

Mathematics and Methods for Elementary School Teachers, A Laboratory Approach, the laboratory manual used in the courses, was written for teachers-in-training and teachers-in-service to actively explore the mathematical concepts presented to students in the elementary school. The mathematical content explored over the two semester sequence is fairly standard: numeration systems, bases, operations with whole numbers , integers, rational numbers, ratios, proportions, percents, number theory, measurement, geometry, probability, statistics and functions. Problem solving is infused throughout the curriculum. The courses are each 3 credit hours, but meet four hours each week because of the amount of material and the approach taken.

Students are expected to participate in their own learning. The participants are involved in an activity oriented mathematics laboratory where they can explore mathematical ideas

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and learn the meanings and properties of the fundamental arithmetic operations. It is assumed that students will work in small groups in a cooperative atmosphere. Students are expected to help each other, not only within their own group, but should act as resource people for other groups. Explaining an idea to others helps clarify the idea for the explainer. The learning of mathematics is not a spectator sport, but a participatory one. It has been shown that small group cooperative learning is effective with children and adult learners. It is also hoped that the student will adopt small group learning in his/her own classroom.

As previously stated, a variety of concrete materials are used to facilitate the learning of mathematical ideas. The materials are embodiments of the mathematical ideas. Students use these materials to "play" with concepts which helps them construct their mathematical knowledge. I believe that knowledge cannot be presented to students, it is something they must construct to own. A variety of appropriate materials are used in the laboratory activities to expose the mathematical ideas being considered and to emphasize that learning is unique to the learner and using multiple materials and approaches to the same concept will enrich the classroom environment for all the students.

To emphasize that mathematics is not limited to school learning, that is, mathematics has direct meaning in our lives, students are asked to read newspapers and news weeklies to find the mathematics around them. The underlying assumption to these exercises is that teachers must see the relevance of mathematics to help uncover it for their students.

Students have also been writing a journal to reflect upon their own learning of mathematics. Students write on a computer, and hand in the disc at least once a month. Thus the journal allows for a conversation between the instructor and the student. Learning to become a reflective practitioner takes time, and these courses are just a beginning step toward this goal.

Mathematics and Methods for Elementary School Teachers, A Laboratory Approach **integrates mathematics and methods**. Mathematical ideas needed for the development of an elementary school topic are introduced and developed using the appropriate concrete and pictorial models. This allows the user to (re)learn the mathematics in a non-threatening manner. It also introduces teachers-in-training and teachers-in-service to materials which will benefit elementary school students when learning mathematics. Over the course of the two semesters, students are expected to develop lesson plans, summarize and "critique" articles from mathematics journals, interview elementary school students, develop a graphing project, participate in a clinical experience and analyze a textbook series on a particular topic.

It is not intended that the laboratory manual stand alone. A text which emphasizes the teaching/learning of mathematics can help put the activities from the manual into perspective, offering background readings in various theories of how children learn mathematics, the construction of lessons and some activities and exercises to extend laboratory experiences to elementary school students. Textbooks in use in the elementary schools are needed for many of the experiences in the manual. These provide opportunities for exploring the mathematics taught throughout the grades, possible

sequencing within mathematical topics, and comparisons between approaches used in various textbooks as well as adherence to the vision of school mathematics presented by the National Council of Teachers of Mathematics in *Curriculum and Evaluation Standards for School Mathematics* (1989). Readings in professional mathematics journals, such as Arithmetic Teacher (AT), Teaching Children Mathematics (TCM), Mathematics Teaching in the Middle School (MTMS), Mathematics Teacher (MT), and School Science and Mathematics(SSM), are a necessary ingredient for professional growth. They enable the reader to put the mathematical ideas into context of the classroom, reinforce that there is no one right way to teach mathematics, and allow for a continuation of dialogue of mathematical ideas and teaching strategies.

The role of the instructor varies throughout the course. At times the instructor acts as a resource person, helping students answer their own questions, and encouraging the "playing" with mathematical ideas that characterizes the excitement of learning, in general, and mathematics, in particular. Sometimes the instructor might lecture or encourage a class discussion, or help summarize and/or generalize some of the ideas that were "bantered" about during the class.

There is no typical day to present as the classroom takes on a life determined by the activity or problem at hand, the students and their questions interacting with the teacher. For example, in a number theory unit, while working on divisibility, the question came up as to how do you know if a number is divisible by 11. A single digit multiple is obvious, but how can other multiplies be explained. Students at a tables took responsibility for different multiples: three digit, four digit and five digits, looking for patterns to help in determining a generalization. The students exchanged work to see if their generalizations could be applied to new data. The class then worked together to determine a generalization. However, what was not "working" were numbers like 902 or 8250. We then briefly talked about modular arithmetic to help tie the discussion together and iron out the wrinkles that tend to bubble up during an inductive exploration.

Most of the teachers-in-training do not have an idea of what students in the elementary school know or understand. One of the first assignments given to the students is to interview five elementary school students and ask questions related to: numbers related to the student, estimating costs, measuring, number sense, attitudes toward mathematics, reading and writing numerals, counting, magnitude, mental calculations, and algorithms, both exercises and word "problems." Results from these interviews which are analyzed and written up by the students, are referred to throughout the two semester course. For example, when asking the elementary school students to place 1/2 on a number line, third grade students usually will place 1/2 between the one and the two on the number line. These results are discussed during the unit on rational numbers which takes place during the second semester.

A culminating activity to the functions, graphing and statistics unit is a graphing project. Students choose a question which they want to answer or a position they would like to take, devise a data-collection experiment which would shed light on the question or support or refute the position, and collect, organize and present the findings to the class. They also discuss how they would adapt the activity for use in an elementary classroom at

two distinct grade levels, how they would introduce it to the students, the need for presenting the information in a graph, and questions they might ask students in each of the grades about the graphs, as well as possible follow-up activities.

An activity which I enjoy is called "Adopt a Solid." The students are asked to choose a solid from the classroom's supply of models. They are given two weeks to find out as much as they can about the solid. They should be able to describe it in many ways. For example, how many faces does it have and what shapes are they? How many vertices (corners) does it have? How many edges? Etc. They are asked to make a model of the solid. And find out what role it plays in the real world? (its uses, does it look like any building?, etc.) To present this information to the class they write an essay or poem about the solid addressing why the solid is special. The presentations are usually at the end of the second semester, and are a wonderful way to end the year.

During the fall of 1990 over 2400 mathematics educators at the University level associated with the National Council of Teachers of Mathematics were queried as to their awareness of the current mathematics education reform publications, and how the information from publications were integrated into the mathematics methods classes. Of the 432 responses which were received, twenty percent (88 responses, 20.4%) were from educators who indicated that they taught an integrated mathematics content and methods course. If one just considers the elementary responses (rather than elementary and secondary courses) there were twenty-five percent (56 responses out of 221 responses) who taught an integrated mathematics and methods course. This is the only indicator that could be found which told of the percentage of integrated courses taught.

As States move toward more general mathematics requirements for elementary school teachers, this percentage should drop. I am sorry to see this trend. Integrated mathematics and methods courses tend to be rich in content, rich in their applications to classroom teaching, and meaningful in their approach to the learning of mathematics. Students with a desire to have a concentration or minor in mathematics can pursue mathematics courses in addition to those which address the mathematics learned/taught in the elementary school curriculum. I agree that elementary school teachers desperately need more mathematics. But I disagree that changing the requirement of what mathematics is basic to the teaching in an elementary school is the means to turn teachers-in-training onto mathematics. On the AMTE listserv there has been much talk about not having enough time to include everything we need to teach in a mathematics methods course. It will never be possible to include all that prospective teachers need to see and do, either in mathematics or in the methods of teaching mathematics. But what we can offer is a model by which teachers-in-training can learn and feel successful in their learning, work towards becoming problem solvers, and hopefully learn to enjoy (I want to say love) mathematics.

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